36475 Intake
R7 · IA · Duane Arnold

DUANE ARNOLD ENERGY CENTER
CEDAR RIVER OPERATIONAL ECOLOGICAL STUDY
ANNUAL REPORT

January 1984 - December 1984

Submitted by

Donald B. McDonald
Iowa City, Iowa

April, 1985

TABLE OF CONTENTS

INTRODUCTION

This report presents the results of the physical, chemical, and biological studies of the Cedar River in the vicinity of the Duane Arnold Energy Center during the 11th year of station operation (January 1984 to December 1984).

The Duane Arnold Energy Center Operational Study was implemented in mid-January 1974. Prior to plant start-up, extensive pre-operational data were collected beginning in April, 1971. These pre-operational studies provided a substantial amount of "baseline" data with which to compare the information collected since the station became operational. The availability of 11 years of operational data, collected under a variety of climatic and hydrological conditions, provides an excellent basis for the assessment of the effects of the operation of the Duane Arnold Energy Center on the limnology and water quality of the Cedar River. Equally important is the availability of sufficient data to identify long-term trends in the water quality of the Cedar River which are unrelated to station operation but are indicative of climatic patterns or changes in land use practices or pollution control procedures within the Cedar River basin.

SITE DESCRIPTION

The Duane Arnold Energy Center, a nuclear fueled electrical generating plant, operated by the Iowa Electric Light and Power Company, is located on the west side of the Cedar River, about 2½ miles north-northeast of Palo, Iowa, in Linn County. The plant employs a boiling water nuclear power reactor producing about 500 MWe of power at full capacity. Waste heat rejected from the turbine cycle to the condenser circulating water is removed by two closed loop induced draft cooling towers, which require a maximum of 11,000 gpm (about 24.5 cfs) of water from the Cedar River. A maximum of 7,000 gpm (about 15.5 cfs) may be lost through evaporation, while 4,000 gpm (about 9 cfs) will be returned to the river as blowdown water from the cool side of the cooling towers.

OBJECTIVES

Studies to determine the baseline physical, chemical, and biological characteristics of the Cedar River near the Duane Arnold Energy Center prior to plant start-up were instituted in April of 1971. These pre-operational studies are described in earlier reports.[1-3] Data from these studies served as a basis for the development of the operational study.

The operational studies were designed to identify and evaluate any significant effects of chemical or thermal discharges from the generating station into the Cedar River as well as the magnitude of impingement on intake screens or entrainment in the condenser make-up water and were first implemented in January, 1974.[4-13]

The specific objectives of the operational study are twofold:

1. To continue routine water quality determinations in the Cedar River in order to identify any conditions which could result in environmental or water quality problems.
2. To conduct physical, chemical, and biological studies in and adjacent to the discharge canal and to compare the results with similar studies above the intake. This will make it possible to determine any water quality changes occurring as the result of chemical additions or condenser passage and to identify any impact of the plant effluent on aquatic communities adjacent to the discharge.

STUDY PLAN

During the operational phase of the study, sampling sites were established in the discharge canal and at four locations in the Cedar River (Figure 1): (1) upstream of the plant at the Lewis Access Bridge (Station 1); (2) directly above the plant intake (Station 2); (3) at a point approximately 140 feet below the plant discharge (Station 3); and (4) adjacent to Comp Farm, about ½ mile below the plant (Station 4). Samples are also taken from the discharge canal (Station 5).

Prior to 1979 samples were collected and analyzed by the Department of Environmental Engineering, University of Iowa. From January 1979 through December 1983 samples were collected and analyzed by Ecological Analysts, Inc. In 1984 collection and analysis of samples was conducted by the University of Iowa Hygienic Laboratory, located in Iowa City, Iowa. The conclusions contained in this annual report are based on the results of their analysis.

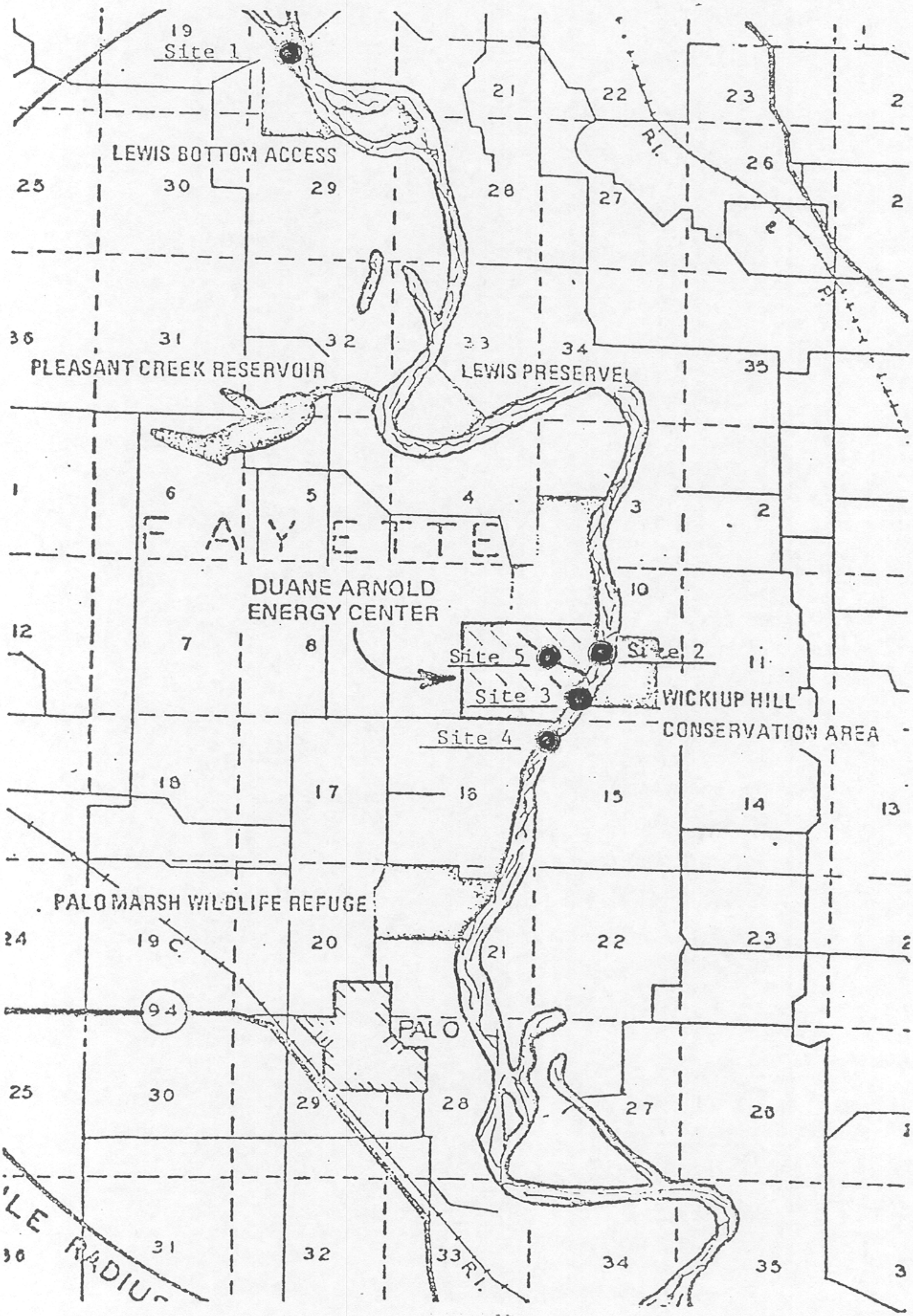

Figure 1. Location of Operational Sampling Sites

Samples for general chemical, physical, and biological analysis were taken twice per month while other studies were conducted three times per year. The following studies are discussed in this report:

I. General Water Quality Analysis

A. Frequency: Twice per month

B. Location: At all five locations

C. Parameters measured:

1. Temperature
2. Turbidity
3. Solids (total, dissolved, and suspended)
4. Dissolved Oxygen
5. Carbon Dioxide
6. Alkalinity (total and carbonate)
7. pH
8. Hardness Series (total and calcium)
9. Phosphate Series (total and ortho)
10. Ammonia
11. Nitrate
12. Iron
13. Biochemical Oxygen Demand
14. Coliform Series (total and fecal)

II. Heavy Metal Determinations

A. Frequency: Spring, summer, and fall

B. Location: At all five locations

C. Parameters measured:

1. Chromium (Cr^{+6})
2. Copper
3. Lead
4. Manganese
5. Mercury
6. Zinc

III. Biological Studies

A. Benthic studies

1. Frequency: Summer and fall

2. Location: All locations

B. Impingement studies

1. Frequency: Daily

2. Location: Intake

C. Asiatic Clam (Corbicula) Survey

1. Frequency: Three times yearly

2. Location: Upstream and downstream of station, intake bay, and cooling tower basin.

OBSERVATIONS

Physical Conditions

Hydrology (Table 1)

Flows in the Cedar River during the period January-December, 1984, were generally lower than those of 1983, but continued to be above normal. Mean monthly discharges at the Cedar Rapids gauging station ranged from 1,419 cfs in September to 17,972 cfs in June. Estimated mean flow for the year was ca. 7,325 cfs, substantially above the 8 year average flow of 3,414 cfs. Discharges were classified as excessive (greater than the 75% quartile) in January and February, from April through July, and in December, and were in excess of the 1951-80 median monthly discharges in all months except September. Mean monthly discharges ranged from 80% of the 1951-80 monthly median flow in September to 961% of the monthly median flow in February. Extremely high late winter flows were observed in February when record mean monthly and daily flows were reported. The maximum yearly flow of 30,500 cfs occurred on February 22. High flows also occurred from late March through June with a summer peak of 30,100 cfs observed on June 22. Dry conditions during the late summer and early fall resulted in substantially lower river stages, but in spite of limited rainfall, flows remained relatively high due to input of bank storage. A low flow for the year of 778 cfs occurred on December 7. Hydrological data are summarized in Table 1.

Temperature (Table 2)

River temperatures during the period ranged from 0.0°C (32.0°F) to 24.0°C (75.2°F). The maximum temperature, which was observed upstream of the intake (Station 2) on August 2 was somewhat lower than those of previous years. The highest discharge canal (Station 5) temperature observed during the period, 29.0°C (84.2°F), was also recorded on August 2. A maximum temperature differential (ΔT value) between the upstream river and the discharge canal (Station 2 vs. Station 5) of 23.0°C (41.4°F) was observed on October 30.

Because of the relatively high river flows present throughout most of the year, station operation rarely had a significant effect on downstream river temperature and virtually no effect outside of the mixing zone. A maximum ΔT value between ambient upstream temperature (Station 2) and the downstream station (Station 3) located in the mixing zone for the discharge canal of 11.5°C (20.7°F) was measured on October 30 and differentials of 5°C (9°F) or greater were only observed at this station on two other occasions. A maximum temperature elevation at the Comp Farm station ½ mile below the plant (Station 2 vs. Station 4) of 1.5°C (2.7°F) was observed on February 21. In over 30% of the samples, temperatures at Station 4 were actually lower than those observed upstream.

A summary of water temperature differentials between upstream and downstream locations is given in Table 3.

Turbidity (Table 4)

Turbidity values exhibited more variation than during the previous year. Peak values occurred during May, June, and July, and were substantially higher than those observed in 1983. A maximum river turbidity value of 270 NTU was observed in mid-July at the beginning of a period of increasing runoff. Minimum turbidity values from 2 to 4 NTU were observed in the river in January and early February. Turbidity values in the discharge canal were usually similar to or slightly higher than those observed in river samples, but no effects on downstream turbidity levels were apparent.

Solids (Tables 5-7)

Solids determinations included total, dissolved, and suspended. Total solids values in upstream river samples ranged from 300 to 1100 mg/L with the majority falling between 350 and 450 mg/L.

Dissolved solids values were relatively low, due primarily to the high river flows and subsequent dilution effects. Upstream values ranged from 190 mg/L in May to 420 mg/L in December. Downstream dissolved solids values at Station 3, 140 feet downstream of the discharge canal, were occasionally higher than upstream values observed above the discharge canal. A maximum downstream value of 820 mg/L was observed at this location on August 23. Because of high river flows dissolved solids values at Station 4, ½ mile below the plant, were similar to upstream levels. Suspended solids values in the river were usually higher than those present in 1983, ranging from 2 to 680 mg/L and generally paralleled turbidity levels.

Due to concentration in the blowdown, solids values in the discharge canal were frequently higher than in the river samples during periods of station operation. A maximum total solids concentration of 1800 mg/L was observed in the discharge canal on August 23 while a minimum value of 300 mg/L was observed in February.

Chemical Conditions

Dissolved Oxygen (Table 8)

During 1984 dissolved oxygen concentrations in the river exhibited less variation than in 1983, ranging from 6.8 to 13.8 (77 to 95% saturation). Lowest concentrations were observed from mid-June through mid-July during periods of high flow. Unlike the previous year, extremely high dissolved oxygen concentrations associated with photosynthetic activity were infrequent, although in early August oxygen saturation values approached 140% during a period when flows were relatively low. Highest values (ca. 11 to 13 mg/L) usually occurred during the late fall and winter periods when water temperatures were low and the solubility of the gas was increased. Dissolved oxygen concentrations in the discharge canal (Station 5) ranged from 6.4 to 14.1 mg/L, and were generally at or near saturation levels.

Carbon Dioxide (Table 9)

Carbon dioxide concentrations ranged from <1 to 29 mg/L. Highest values occurred from January through March, while values of <1 mg/L commonly occurred in August, September, and November.

Alkalinity, pH, Hardness (Tables 10-14)

These parameters are closely related and were influenced by hydrological, climatic, and biological conditions. Highest total alkalinity values in the river (ca. 230-300 mg/L) occurred during late January and early February when groundwater made up a significant portion of river flow. Lowest values (ca. 80-90 mg/L) occurred during extremely high flows in February, resulting from snowmelt and runoff.

With the exception of a few samples taken from August through November, all river carbonate alkalinity values were below 1 mg/L. Maximum values of ca. 8-9 mg/L accompanied periods of high photosynthetic activity.

Values for pH in river samples ranged from 7.0 in February to 8.8 in August and September. High values usually coincided with periods of increased photosynthetic activity in the summer, while low values occurred during late winter runoff. In the discharge canal pH values ranged from 7.1 to 9.0.

Total hardness values in the river generally paralleled total alkalinity levels with highest values (ca. 300-400 mg/L) occurring in the winter. Low values of 130 mg/L was observed during mid-February. Hardness values in the discharge canal were frequently higher than river values due to reconcentration in the blowdown. Total hardness levels at this location ranged from 150 to 950 mg/L.

Phosphates (Tables 15 and 16)

Total phosphate concentrations in river samples continued to be relatively low during 1984. Concentrations ranged from 0.15 mg/L in early January to 0.94 mg/L in July. In the past, high phosphate values frequently occurred during high flow periods, but this pattern was not observed in 1984.

Orthophosphate concentrations in river samples ranged from 0.01 mg/L in August and September to a maximum value of 0.38 mg/L on October 30. As in previous years, reduced orthophosphate concentrations frequently coincided with large plankton populations as a result of uptake by algae.

Phosphate values in the discharge canal were consistently higher than in the river, but differences between upstream and downstream locations were minimal. A maximum total phosphate concentration of 2.4 mg/L was observed in the discharge canal in early May.

Ammonia (Table 17)

Ammonia nitrogen concentrations in the river were relatively low throughout the year, ranging from <0.01 to 0.42 mg/L. Highest concentrations accompanied snowmelt and high flows in mid-February while low values occurred at intervals during the summer and fall and appeared to be related to uptake of ammonia by algae.

Nitrate (Table 18)

The trend in steadily increasing nitrate nitrogen concentrations which had been observed for the past several years appeared to have been reversed during 1984. During the current year, nitrate nitrogen values in river samples ranged from ca. 1.1 mg/L in mid-September to 9.7 mg/L in June. The average nitrate nitrogen concentration at Station 2, upstream of DAEC, was 6.0 mg/L. This compares to an average value of 8.4 mg/L in 1983 when 23% of all river samples exhibited concentrations in excess of the EPA drinking water standards of 10 mg/L.[14] During 1984, concentrations in excess of 9 mg/L were observed only in June. Nitrate concentrations were frequently higher in the discharge canal than in river samples due to reconcentration in the blowdown. A maximum nitrate nitrogen concentration of ca. 21.0 mg/L was observed in the discharge canal in late May.

Iron (Table 19)

Iron concentrations in the river continued to be high, ranging from 0.08 to 8.0 mg/L. Highest concentrations occurred in early May and mid-July in conjunction with high river flow. Low values usually occurred during periods of low flow in the winter. High iron concentrations were usually observed in association with high turbidity values indicating that most of the iron present was in the suspended form rather than in solution. Due to reconcentration in the blowdown discharge iron levels were usually higher in the discharge canal than in the river samples. A maximum iron concentration of 16.0 mg/L was observed in the discharge canal on May 1.

Biological Conditions

Biochemical Oxygen Demand (Table 20)

Five-day biochemical oxygen demand (BOD_5) values in the river ranged from <1 to 14 mg/L. Relatively high values (6 mg/L) were associated with late winter runoff in February but in general the winter to early spring period was characterized by low BOD levels of 3 mg/L or less. Maximum values coincided with low river flow and large algal populations in late August and early September.

Coliform Organisms (Tables 21 and 22)

Determination of total and fecal coliform bacterial populations were reinstituted in 1984 after being discontinued in 1978. As in previous years, populations were relatively large with the highest counts accompanying periods of increased river flow. This pattern is indicative of runoff from agricultural land in the river drainage basin. Maximum total and fecal coliform counts of 40,000 and 5,300 organisms/100 ml respectively, were observed on July 16. Low total and fecal coliform counts of <1,000 and <100 respectively, were observed at intervals in the fall and winter.

ADDITIONAL STUDIES

In addition to the routine monthly studies, a number of seasonal limnological and water quality investigations were conducted during 1984. The studies discussed here include heavy metal determinations, benthic and impingement studies, and an Asiatic clam (Corbicula) survey.

Heavy Metal Determinations

Samples for heavy metals analysis were collected on April 17, July 16, and October 16, and analyzed for hexavalent chromium, copper, lead, manganese, mecury, and zinc. In general, concentrations fell within the expected ranges and were similar to those observed during 1983.

Heavy metal concentrations in the April samples were relatively low due largely to the high river flow present and exhibited little variation between locations. All samples taken on July 16 exhibited copper concentrations slightly in excess of the 20 μg/L water quality standard,[15] but the levels were not sufficiently high to adversely affect the biota of the Cedar River. High copper values have frequently been observed in the Cedar River and are not related to the operation of the Duane Arnold Energy Center. No other heavy metals in the July sample exceeded the water quality standards. The relatively high manganese concentrations observed at all locations were apparently related to the high suspended solids level in the river at the time of sampling. Heavy metal concentrations in the October samples were equal to or lower than those observed during the July study and exhibited little variation between stations. No parameters exceeded the water quality standards. The relatively high copper and manganese concentrations observed in July were not present during the October study.

Benthic Studies

Bottom samples were taken at two locations, upstream and downstream of the station in July and October by means of a Ponar dredge. A total of six taxa and 78 organisms were collected. Dredge samples were dominated by chironomid (midge) larvae, which accounted for 77% of the benthic biota collected. A few caddis fly larvae were also collected where suitable substrate was available. Although seasonal changes and variations in total numbers were observed between stations, no consistent differences were observed which appear to be related to station operation. The results are generally compatible with earlier studies which indicate that variation in bottom substrate is the major factor influencing species composition and that the shifting sand and silt bottom is the primary cause of the limited diversity of the benthic community. Differences between the kinds and numbers of organisms collected by Ponar dredge during 1984 as compared to earlier studies appear to be related to sampling and sorting techniques.

Artificial substrates (Hester-Dendy) were placed upstream and downstream of the station and in the discharge in May and September and collected in July and October, respectively. As in previous years, substrate samples were characterized by a different community structure and greater species diversity than the natural substrate (Ponar dredge) samples. A total of 31 taxa were identified. No major seasonal or locational differences were apparent. The diversity, species composition, and total numbers present on the discharge canal substrates were similar to those observed on substrates from the river. Caddis fly larvae were the dominant organisms in the fall samples, while mayfly nymphs were most common during the summer.

As in previous years, the artificial substrate studies indicate that the Cedar River, both upstream and downstream of the Duane Arnold Energy Center, is capable of supporting a relatively diverse macroinvertebrate fauna in those limited areas where suitable bottom habitat is available. The results of the benthic studies are given in Table 24.

Impingement Studies

Although slightly higher than those of previous years, the total number of fish impinged on the intake screens at the Duane Arnold Energy Center remained low. Daily counts conducted by DAEC station personnel indicate that a total of 746 fish were impinged during 1984. Highest impingement rates continued to occur during the winter. During the period January through March and December 411 fish were removed from the trash baskets. The month with the highest impingement rate, however, was August, when 163 fish were collected in the trash baskets. The results of the daily trash basket counts are given in Table 25.

Asiatic Clam Survey

In recent years several power generation facilities have experienced problems with blockage of cooling water intake systems by large numbers of Asiatic clams (*Corbicula* sp.). Although this clam is common in portions of the Iowa reach of the Mississippi River, it is normally absent from areas with shifting sand/silt substrates such as occur in the Cedar River in the vicinity of the Duane Arnold Energy Center. *Corbicula* has not been collected from the Cedar River in the vicinity of the DAEC during the routine Cedar River monitoring program, which was implemented in April, 1971. A single *Corbicula* was, however, collected in January of 1979 in the vicinity of Lewis Access, upstream of DAEC, by Hazelton personnel. Because *Corbicula* had been collected on one occasion from the Cedar River and is commonly found in power plant intakes on the Mississippi River, studies were implemented at the Duane Arnold Energy Center in 1981 in order to determine if the organism had established itself within the system. No *Corbicula* were collected during the 1981, 1982, or 1983 investigations.

The studies were continued during 1984 and continued to be negative. Samples were taken on June 4, October 30, and November 20, 1984. On each sampling date four samples were collected in the area between the bar screens and the traveling screens at the intake, two were taken in the discharge canal, and two in the Cedar River, one upstream and one downstream of the station (Stations 2 and 3). No Asiatic clams were identified from the samples. Visual inspections of the shoreline along the river and discharge canal, and around the base of the cooling towers did not indicate the presence of any of these organisms.

DISCUSSION AND CONCLUSIONS

The studies conducted on the Cedar River during 1984 continue to support the conclusion that the major factors affecting the limnology and water quality of the river in the vicinity of the Duane Arnold Energy Center, are runoff from agricultural land in the drainage basin along with seasonal and yearly variations in climatic and hydrological characteristics. The effects of agricultural land runoff on the Cedar River have been discussed in the earlier preoperational[1,2] and operational reports,[4,5,7,8] and need not be repeated in detail here. However, as in earlier years, maximum turbidity, suspended solids, ammonia, BOD, and coliform values usually occurred at the beginning of runoff periods, especially in the late winter and early spring. These conditions are not unique to the Cedar River and are commly found in other midwestern rivers receiving substantial runoff from agricultural land.[16,17]

In contrast, those streams which are influenced primarily by "point-source" pollution, such as input from domestic or industrial waste discharges, usually exhibit water quality problems during low flow rather than high flow periods. This pattern has not been apparent during the Cedar River studies. In those cases where operation of the Duane Arnold Energy Center has resulted in increased levels of various parameters in the discharge canal, downstream effects have, in most cases, been confined to the mixing zone. This pattern continued during the 1984 studies, and no violations of the Iowa Water Quality Standards[15] were observed which were attributable to the operation of the Duane Arnold Energy Center. During the 1984 study, copper was the only parameter found to be in violation of the water quality standards. In July copper concentrations of 30 to 40 mg/L were observed at all sampling locations, but values were similar at upstream and downstream locations, indicating that the Duane Arnold Energy Center was not the source of these high levels (the Iowa Water Quality Standard for copper is 20 mg/L). Fecal coliform levels frequently exceeded the Class A water quality standards of 200 organisms/100 ml, but the standards specifically exempts waters which are "materially affected by surface runoff," and the high levels observed in the Cedar River near the station were obviously the result of runoff from agricultural land. Coliform concentrations downstream of the station were similar to levels observed upstream.

No other violations of the water quality standards were observed during the 1984 study. Station operation rarely had a significant effect on downstream water temperatures, and the maximum temperature increase observed downstream of the mixing zone (Station 4) was 1.5°C, well below the 3°C standard. For the first time since 1980 all nitrate concentrations in river samples were below the 10 mg/L (as N) drinking water standards.[14] Average nitrate values were also the lowest present since 1980 (Table 26). These lower values may be related to reduced use of nitrogen based fertilizers during 1983, when the Government's Payment in Kind (PIK) program resulted in substantial reductions in the amount of farm land planted in corn.

A comparison of years with similar mean flows immediately before and after the PIK program (1982 and 1984) indicates that reductions in concentrations of ammonia and phosphate in the river also occurred as a result of PIK. These reductions are especially evident when the relative loading values (obtained by multiplying average concentrations of the various parameters by cumulative runoff) for 1982 and 1984 are compared (Table 27).

REFERENCES CITED

1. McDonald, D.B., "Cedar River Baseline Ecological Study Annual Report, April 1971-April 1972. Duane Arnold Energy Center." Report prepared for Iowa Electric Light and Power Company by the University of Iowa, 1972.

2. McDonald, D.B., "Cedar River Baseline Ecological Study Annual Report, May 1972-April 1973. Duane Arnold Energy Center." Report prepared for Iowa Electric Light and Power Company by the University of Iowa, 1974.

3. McDonald, D.B., "Cedar River Baseline Ecological Study Final Pre-Operational Report, May 1973-January 1974." Report prepared for Iowa Electric Light and Power Company by the University of Iowa, 1974.

4. McDonald, D.B., "Cedar River Baseline Ecological Study Annual Operational Report, January 1974-January 1975. Duane Arnold Energy Center." Report prepared for Iowa Electric Light and Power Company by the University of Iowa, 1975.

5. McDonald, D.B., "Cedar River Baseline Ecological Study Annual Report, January 1975-January 1976. Duane Arnold Energy Center." Report prepared for Iowa Electric Light and Power Company by the University of Iowa, 1976.

6. McDonald, D.B., "Cedar River Baseline Ecological Study Annual Report, January 1976-December 1976. Duane Arnold Energy Center." Report prepared for Iowa Electric Light and Power Company by the University of Iowa, 1977.

7. McDonald, D.B., "Cedar River Baseline Ecological Study Annual Report, January 1977-December 1977. Duane Arnold Energy Center." Report prepared for Iowa Electric Light and Power Company by the University of Iowa, 1978.

8. McDonald, D.B., "Duane Arnold Energy Center Cedar River Operational Ecological Study Annual Report," January 1978-December 1978. In: Reports of Environmental Monitoring Program, January 1978-December 1978, Iowa Electric Light and Power Company, 1979.

9. McDonald, D.B., "Duane Arnold Energy Center Cedar River Operational Ecological Study Annual Report, January 1979-December 1979." Report prepared for Iowa Electric Light and Power Company by D.B. McDonald Research, Inc., Iowa City, May 1980.

10. McDonald, D.B., "Duane Arnold Energy Center Cedar River Operational Study Annual Report, January 1980-December 1980." Report prepared for Iowa Electric Light and Power Company by D.B. McDonald Research, Inc., June 1981.

11. McDonald, D.B., "Duane Arnold Energy Center Cedar River Operational Study Annual Report, January 1981-December 1981." Report prepared for Iowa Electric Light and Power Company, May 1982.

12. McDonald, D.B., "Duane Arnold Energy Center Cedar River Operational Study Annual Report, January 1982-December 1982." Report prepared for Iowa Electric Light and Power Company, May 1983.

REFERENCES CITED (cont.)

13. McDonald, D.B., "Duane Arnold Energy Center Cedar River Operational Study Annual Report, January 1983-December 1983." Report prepared for Iowa Electric Light and Power Company, March 1984.

14. National Interim Primary Drinking Water Standards. Rederal Register. U.S. Environmental Protection Agency, Vol. 40, No. 248 (Dec. 24, 1975).

15. State of Iowa, "Water Quality Standards," Chapter 15, 400 Iowa Administrative Code. State of Iowa, Des Moines, Iowa. March, 1978.

16. McDonald, D.B., "Trends in Water Quality Characteristics of the Coralville Reservoir and Iowa River." In: Water Quality in the Corps of Engineers Reservoirs in Iowa. Proceedings of the March, 1980 Seminar.

17. McDonald, D.B., Coralville Reservoir Water Quality Study, October 1, 1980 to October 31, 1981, Iowa Institute of Hydraulic Research Limited Distribution Report #99, August, 1982.

Table 1

Summary of Hydrological Conditions
Cedar River at Cedar Rapids*
1984

Date 1984	Mean Monthly Discharge (cfs)	Percent of 1951-1980 Median Discharge
January	4,797	459
February	11,730	961
March	7,644	144
April	12,358	211
May	14,528	340
June	17,972	423
July	7,897	241
August	2,480	123
September	1,419	80
October	1,817	122
November	2,762	150
December	2,496	199

*Data obtained from U.S. Geological Survey records.

Table 2

Temperature (C^{o}) Values from the Cedar River Near the Duane Arnold Energy Center During 1984

	Sampling Locations				
Date	Upstream of Plant 1	Upstream of Plant Intake 2	Discharge Canal 5	140 ft. Downstream of Discharge 3	1/2 Mile Downstream from Plant 4
JAN 10 84	0.5	0.5	0.5	0.5	1.0
JAN 24 84	0.5	1.0	1.0	2.0	0.5
FEB 07 84	0.0	0.0	14.0	2.0	0.5
FEB 21 84	2.0	1.5	5.5	3.0	3.0
MAR 06 84	2.0	3.0	4.0	3.0	1.5
MAR 20 84	1.5	1.5	2.5	2.0	1.0
APR 03 84	7.0	6.5	11.0	7.0	6.5
APR 17 84	9.5	11.0	13.5	11.0	11.0
MAY 01 84	9.0	10.0	17.0	11.0	9.5
MAY 15 84	16.0	17.5	25.0	18.0	18.0
JUN 05 84	21.0	19.0	19.0	19.5	20.0
JUN 15 84	20.0	21.0	26.0	21.0	21.0
JUL 02 84	21.0	21.0	27.0	21.0	21.0
JUL 16 84	22.5	22.5	26.5	23.0	22.5
AUG 02 84	23.0	24.0	29.0	24.0	23.0
AUG 23 84	19.5	19.5	25.0	22.0	19.0
SEP 13 84	21.0	20.5	28.0	21.0	20.0
SEP 27 84	10.5	11.0	11.0	11.0	10.0
OCT 16 84	12.5	12.0	11.5	14.0	13.0
OCT 30 84	7.0	7.5	30.5	19.0	8.5
NOV 13 84	3.0	4.0	8.0	5.0	4.0
NOV 27 84	5.0	5.0	25.0	12.0	6.0
DEC 04 84	0.0	0.0	20.5	5.0	0.0
DEC 20 84	0.0	0.0	2.0	1.0	0.0

Table 3

Summary of Water Temperature Differentials and Station Output During Periods of Cedar River Sampling During 1984

Date 1984	ΔT (°C) U/S River (St. 2) vs. Dis. Canal (St. 5)	ΔT (°C) U/S River (St. 2) vs. D/S River (St. 3)	ΔT (°C) U/S River (St. 2) vs. D/S River (St. 4)	Station Output (% full power)
JAN 10	0.0	0.0	0.5	9
JAN 24	0.0	0.0	-0.5	1
FEB 07	14.0	2.0	0.5	99
FEB 21	4.0	1.5	1.5	99
MAR 06	1.0	0.0	-1.5	100
MAR 20	1.0	0.5	-0.5	100
APR 03	4.5	0.5	0.0	100
APR 17	2.5	0.0	0.0	0
MAY 01	7.0	1.0	-0.5	62
MAY 15	7.5	0.5	0.5	74
JUN 05	0.0	0.5	1.0	0.5
JUN 15	5.0	0.0	0.0	27
JUL 02	6.0	0.0	0.0	86
JUL 16	4.0	0.5	0.0	83
AUG 02	5.0	0.0	-1.0	100
AUG 23	5.5	2.5	-0.5	100
SEP 13	7.5	0.5	-0.5	68
SEP 27	0.0	0.0	-1.0	73
OCT 16	-0.5	2.0	1.0	0
OCT 30	23.0	11.5	1.0	43
NOV 13	4.0	1.0	0.0	24
NOV 27	20.0	7.0	1.0	52
DEC 04	20.5	5.0	0.0	80
DEC 20	2.0	1.0	0.0	88

Table 4

Turbidity (N.T.U.) Values from the Cedar River
Near the Duane Arnold Energy Center During 1984

Date	Upstream of Plant 1	Upstream of Plant Intake 2	Discharge Canal 5	140 ft. Downstream of Discharge 3	1/2 Mile Downstream from Plant 4
JAN 10 84	3	4	5	4	4
JAN 24 84	2	3	7	15	3
FEB 07 84	2	2	4	2	2
FEB 21 84	65	60	50	60	60
MAR 06 84	13	14	11	13	14
MAR 20 84	18	19	16	19	19
APR 03 84	23	23	40	25	22
APR 17 84	27	26	22	24	26
MAY 01 84	180	180	340	180	190
MAY 15 84	27	26	70	26	30
JUN 05 84	3	32	27	31	32
JUN 15 84	130	120	220	120	120
JUL 02 84	55	55	110	55	55
JUL 16 84	270	240	270	240	230
AUG 02 84	15	33	70	32	34
AUG 23 84	23	25	50	32	23
SEP 13 84	19	25	35	21	18
SEP 27 84	18	18	20	19	18
OCT 16 84	14	14	21	14	13
OCT 30 84	11	10	25	18	11
NOV 13 84	8	9	12	12	9
NOV 27 84	11	12	12	11	12
DEC 04 84	6	7	15	9	7
DEC 20 84	7	9	9	10	9

Table 5

Total Solids (mg/L) Values from the Cedar River
Near the Duane Arnold Energy Center During 1984

Date	Upstream of Plant 1	Upstream of Plant Intake 2	Discharge Canal 5	140 ft. Downstream of Discharge 3	1/2 Mile Downstream from Plant 4
JAN 10 84	390	380	390	380	370
JAN 24 84	460	420	470	570	420
FEB 07 84	340	370	1100	440	390
FEB 21 84	320	300	300	300	280
MAR 06 84	390	390	380	400	400
MAR 20 84	390	390	490	390	380
APR 03 84	330	330	930	320	320
APR 17 84	390	430	360	370	370
MAY 01 84	590	540	1920	530	570
MAY 15 84	460	450	1600	450	460
JUN 05 84	450	470	470	260	460
JUN 15 84	610	600	1000	570	620
JUL 02 84	520	510	1300	520	510
JUL 16 84	1100	940	1400	970	920
AUG 02 84	490	500	1500	540	480
AUG 23 84	400	410	1800	1100	450
SEP 13 84	330	350	1100	380	300
SEP 27 84	320	300	340	320	320
OCT 16 84	350	380	330	360	350
OCT 30 84	380	350	840	610	400
NOV 13 84	360	340	410	390	360
NOV 27 84	390	400	510	430	400
DEC 04 84	420	410	1100	620	470
DEC 20 84	450	440	510	460	450

Table 6

Dissolved Solids (mg/L) Values from the Cedar River
Near the Duane Arnold Energy Center During 1984

	Sampling Locations				
Date	Upstream of Plant 1	Upstream of Plant Intake 2	Discharge Canal 5	140 ft. Downstream of Discharge 3	1/2 Mile Downstream from Plant 4
JAN 10 84	360	360	370	360	350
JAN 24 84	400	380	400	430	390
FEB 07 84	290	340	1000	400	350
FEB 21 84	220	210	180	170	190
MAR 06 84	340	320	340	330	330
MAR 20 84	340	340	440	350	340
APR 03 84	280	290	880	280	270
APR 17 84	290	280	300	310	310
MAY 01 84	220	190	240	210	180
MAY 15 84	360	340	1400	360	360
JUN 05 84	360	360	360	350	350
JUN 15 84	300	270	530	260	280
JUL 02 84	310	300	970	310	310
JUL 16 84	220	240	630	260	230
AUG 02 84	290	310	1200	330	290
AUG 23 84	250	230	1300	820	290
SEP 13 84	200	250	890	250	220
SEP 27 84	220	230	240	250	230
OCT 16 84	290	310	290	280	310
OCT 30 84	346	340	700	520	340
NOV 13 84	320	300	360	340	310
NOV 27 84	360	340	450	380	340
DEC 04 84	290	290	930	480	320
DEC 20 84	420	400	400	410	410

Table 7

Suspended Solids (mg/L) Values from the Cedar River
Near the Duane Arnold Energy Center During 1984

Date	Sampling Locations Upstream of Plant 1	Upstream of Plant Intake 2	Discharge Canal 5	140 ft. Downstream of Discharge 3	1/2 Mile Downstream from Plant 4
JAN 10 84	8	8	16	12	8
JAN 24 84	2	3	50	120	6
FEB 07 84	3	2	68	6	4
FEB 21 84	86	86	76	82	86
MAR 06 84	27	32	20	32	32
MAR 20 84	42	50	40	42	49
APR 03 84	48	44	54	42	46
APR 17 84	48	44	38	40	42
MAY 01 84	310	310	1560	320	340
MAY 15 84	86	88	160	840	82
JUN 05 84	58	60	70	58	60
JUN 15 84	290	260	430	240	240
JUL 02 84	150	160	250	170	160
JUL 16 84	680	620	710	630	590
AUG 02 84	115	130	170	120	110
AUG 23 84	120	130	170	130	120
SEP 13 84	100	100	120	88	94
SEP 27 84	76	58	92	48	88
OCT 16 84	44	40	40	38	34
OCT 30 84	28	20	80	80	44
NOV 13 84	26	30	34	32	28
NOV 27 84	28	30	26	26	32
DEC 04 84	18	14	26	24	18
DEC 20 84	14	26	14	20	12

Table 8

Dissolved Oxygen (mg/L) Values from the Cedar River
Near the Duane Arnold Energy Center During 1984

Date	Sampling Locations: Upstream of Plant 1	Upstream of Plant Intake 2	Discharge Canal 5	140 ft. Downstream of Discharge 3	1/2 Mile Downstream from Plant 4
JAN 10 84	11.6	11.7	13.5	12.4	11.5
JAN 24 84	11.2	11.0	12.9	11.5	11.5
FEB 07 84	11.5	11.5	9.8	10.9	11.3
FEB 21 84	12.1	12.2	12.5	12.3	11.8
MAR 06 84	13.1	13.1	14.1	13.1	13.1
MAR 20 84	12.6	12.7	9.3	12.6	12.7
APR 03 84	11.3	11.1	8.6	11.1	11.3
APR 17 84	10.9	10.9	10.5	10.8	10.7
MAY 01 84	9.8	9.8	10.3	10.3	10.0
MAY 15 84	10.2	9.8	8.0	10.3	10.1
JUN 05 84	8.3	8.2	8.9	8.4	8.4
JUN 15 84	7.1	7.2	7.4	7.3	7.0
JUL 02 84	7.4	7.3	7.1	7.4	7.1
JUL 16 84	7.0	6.8	7.2	7.0	7.2
AUG 02 84	12.1	11.7	6.8	11.7	10.8
AUG 23 84	11.8	11.9	7.3	9.4	10.8
SEP 13 84	9.2	9.0	5.7	8.6	8.6
SEP 27 84	12.0	12.0	11.4	11.8	11.2
OCT 16 84	8.7	8.8	8.3	9.1	8.7
OCT 30 84	10.6	10.8	6.4	8.9	10.4
NOV 13 84	12.6	12.7	11.5	12.0	12.6
NOV 27 84	11.4	11.4	7.5	10.1	11.1
DEC 04 84	13.8	13.6	7.8	12.1	13.4
DEC 20 84	*	*	*	*	*

*Laboratory accident

Table 9

Carbon Dioxide (mg/L) Values from the Cedar River
Near the Duane Arnold Energy Center During 1984

	Sampling Locations				
Date	Upstream of Plant 1	Upstream of Plant Intake 2	Discharge Canal 5	140 ft. Downstream of Discharge 3	1/2 Mile Downstream from Plant 4
JAN 10 84	11	21	12	13	13
JAN 24 84	20	22	26	17	19
FEB 07 84	18	7	8	6	18
FEB 21 84	21	24	19	23	20
MAR 06 84	12	29	11	15	15
MAR 20 84	6	15	12	17	14
APR 03 84	3	3	4	3	2
APR 17 84	2	3	2	2	2
MAY 01 84	7	2	<1	2	5
MAY 15 84	1	1	<2	1	1
JUN 05 84	2	2	<1	2	<1
JUN 15 84	4	3	<1	4	4
JUL 02 84	3	3	<3	3	3
JUL 16 84	2	2	<1	2	2
AUG 02 84	<1	<1	<2	<1	<2
AUG 23 84	<1	<1	2	<1	<1
SEP 13 84	1	1	<5	1	1
SEP 27 84	<1	<1	<1	<1	<1
OCT 16 84	2	2	3	2	2
OCT 30 84	2	2	1	2	2
NOV 13 84	<1	<1	<1	<1	<1
NOV 27 84	<1	<1	3	<1	<1
DEC 04 84	5	7	<5	6	5
DEC 20 84	6	5	4	3	6

Table 10

Total Alkalinity (mg/L-$CaCO_3$) Values from the Cedar River Near The Duane Arnold Energy Center During 1984

Date	Upstream of Plant 1	Upstream of Plant Intake 2	Discharge Canal 5	140 ft. Downstream of Discharge 3	1/2 Mile Downstream from Plant 4
JAN 10 84	224	222	210	214	220
JAN 24 84	256	294	238	230	248
FEB 07 84	230	238	100	194	226
FEB 21 84	90	84	90	80	86
MAR 06 84	208	206	204	206	208
MAR 20 84	196	190	170	186	182
APR 03 84	160	164	98	158	160
APR 17 84	174	174	186	176	178
MAY 01 84	146	146	203	152	151
MAY 15 84	200	186	100	196	200
JUN 05 84	212	196	154	200	202
JUN 15 84	162	160	324	154	164
JUL 02 84	202	206	57	204	197
JUL 16 84	157	161	404	166	166
AUG 02 84	184	181	105	176	174
AUG 23 84	141	140	136	78	107
SEP 13 84	101	104	86	106	102
SEP 27 84	127	129	130	129	129
OCT 16 84	199	205	210	206	200
OCT 30 84	205	202	134	172	202
NOV 13 84	210	210	182	196	201
NOV 27 84	216	212	246	228	214
DEC 04 84	216	224	133	206	210
DEC 20 84	194	194	182	186	188

Table 11

Carbonate (mg/L-$CaCO_3$) Values from the Cedar River
Near the Duane Arnold Energy Center During 1984

	Sampling Locations				
Date	Upstream of Plant 1	Upstream of Plant Intake 2	Discharge Canal 5	140 ft. Downstream of Discharge 3	1/2 Mile Downstream from Plant 4
JAN 10 84	<1	<1	<1	<1	<1
JAN 24 84	<1	<1	<1	<1	<1
FEB 07 84	<1	<1	<1	<1	<1
FEB 21 84	<1	<1	<1	<1	<1
MAR 06 84	<1	<1	<1	<1	<1
MAR 20 84	<1	<1	<1	<1	<1
APR 03 84	<1	<1	<1	<1	<1
APR 17 84	<1	<1	<1	<1	<1
MAY 01 84	<1	<1	<1	<1	<1
MAY 15 84	<1	<1	<1	<1	<1
JUN 05 84	<1	<1	<1	<1	<1
JUN 15 84	<1	<1	26	<1	<1
JUL 02 84	<1	<1	<1	<1	<1
JUL 16 84	<1	<1	49	<1	<1
AUG 02 84	8	5	<1	6	<1
AUG 23 84	4	9	<1	<1	<1
SEP 13 84	<1	<1	<1	<1	<1
SEP 27 84	3	2	<1	<1	2
OCT 16 84	<1	2	<1	<1	<1
OCT 30 84	2	2	4	<1	2
NOV 13 84	2	4	2	4	3
NOV 27 84	8	8	<1	6	8
DEC 04 84	<1	<1	<1	<1	<1
DEC 20 84	<1	<1	<1	<1	<1

Table 12

Units of pH from the Cedar River Near the Duane Arnold Energy Center During 1984

Date	Upstream of Plant 1	Upstream of Plant Intake 2	Discharge Canal 5	140 ft. Downstream of Discharge 3	1/2 Mile Downstream from Plant 4
	Sampling Locations				
JAN 10 84	7.8	7.5	7.7	7.7	7.7
JAN 24 84	7.6	7.6	7.4	7.6	7.6
FEB 07 84	7.6	8.0	7.4	8.0	7.4
FEB 21 84	7.1	7.0	7.1	7.0	7.1
MAR 06 84	7.7	7.3	7.7	7.6	7.6
MAR 20 84	8.0	7.6	7.6	7.5	7.6
APR 03 84	8.1	8.1	7.8	8.2	8.3
APR 17 84	8.3	8.2	8.3	8.3	8.3
MAY 01 84	7.7	8.2	8.5	8.1	7.8
MAY 15 84	7.2	7.3	6.8	7.2	7.3
JUN 05 84	8.3	8.2	8.4	8.2	8.5
JUN 15 84	7.9	8.0	8.9	7.9	7.9
JUL 02 84	8.1	8.1	7.6	8.1	8.1
JUL 16 84	8.1	8.1	9.0	8.1	8.1
AUG 02 84	8.6	8.6	7.9	8.6	8.3
AUG 23 84	8.5	8.8	8.0	8.3	8.4
SEP 13 84	8.3	8.3	7.5	8.3	8.2
SEP 27 84	8.6	8.6	8.5	8.6	8.6
OCT 16 84	8.3	8.4	8.1	8.3	8.3
OCT 30 84	8.4	8.4	8.5	8.3	8.4
NOV 13 84	8.4	8.4	8.4	8.4	8.4
NOV 27 84	8.5	8.5	8.2	8.5	8.5
DEC 04 84	8.1	8.0	7.7	8.0	8.1
DEC 20 84	8.0	8.1	8.1	8.3	8.0

Table 13

Total Hardness (mg/L-CaCO) Values from the Cedar River
Near the Duane Arnold Energy Center During 1984

Date	Upstream of Plant 1	Upstream of Plant Intake 2	Discharge Canal 5	140 ft. Downstream of Discharge 3	1/2 Mile Downstream from Plant 4
	Sampling Location				
JAN 10 84	290	270	280	300	280
JAN 24 84	344	337	346	348	340
FEB 07 84	350	310	726	352	304
FEB 21 84	140	130	150	140	130
MAR 06 84	300	296	300	298	306
MAR 20 84	260	260	320	280	260
APR 03 84	240	240	565	240	240
APR 17 84	250	250	260	250	250
MAY 01 84	210	210	290	210	210
MAY 15 84	290	300	950	290	290
JUN 05 84	268	298	304	302	290
JUN 15 84	245	240	460	240	240
JUL 02 84	298	278	686	282	280
JUL 16 84	235	250	555	245	240
AUG 02 84	250	240	700	270	260
AUG 23 84	205	190	830	550	235
SEP 13 84	188	188	572	184	158
SEP 27 84	180	190	180	180	180
OCT 16 84	256	256	252	260	256
OCT 30 84	285	300	525	420	370
NOV 13 84	280	280	305	285	285
NOV 27 84	290	280	380	320	290
DEC 04 84	302	302	690	414	334
DEC 20 84	385	300	340	305	320

Table 14

Calcium Hardness (mg/L-$CaCO_3$) Values from the Cedar River
Near the Duane Arnold Energy Center During 1984

Date	Sampling Locations				
	Upstream of Plant 1	Upstream of Plant Intake 2	Discharge Canal 5	140 ft. Downstream of Discharge 3	1/2 Mile Downstream from Plant 4
JAN 10 84	197	197	204	210	197
JAN 24 84	222	214	227	240	234
FEB 07 84	200	200	470	230	200
FEB 21 84	88	94	90	90	98
MAR 06 84	225	190	210	235	235
MAR 20 84	170	170	210	180	170
APR 03 84	170	170	390	170	160
APR 17 84	170	170	170	170	170
MAY 01 84	150	150	200	140	140
MAY 15 84	200	210	520	220	200
JUN 05 84	190	205	220	210	195
JUN 15 84	160	160	290	120	120
JUL 02 84	215	200	461	205	200
JUL 16 84	150	160	370	160	160
AUG 02 84	150	155	520	165	165
AUG 23 84	105	98	450	300	113
SEP 13 84	115	90	306	120	125
SEP 27 84	95	95	95	100	95
OCT 16 84	210	180	175	175	175
OCT 30 84	200	190	406	256	245
NOV 13 84	190	190	200	195	195
NOV 27 84	190	170	245	200	200
DEC 04 84	220	190	460	300	210
DEC 20 84	220	240	260	210	220

Table 15

Total Phosphorus (mg/L-P) Values from the Cedar River Near the Duane Arnold Energy Center During 1984

Date	Sampling Locations				
	Upstream of Plant 1	Upstream of Plant Intake 2	Discharge Canal 5	140 ft. Downstream of Discharge 3	1/2 Mile Downstream from Plant 4
JAN 10 84	0.17	0.16	0.17	0.15	0.15
JAN 24 84	0.24	0.25	0.38	0.39	0.28
FEB 07 84	0.27	0.25	0.69	0.31	0.26
FEB 21 84	0.57	0.56	0.52	0.58	0.57
MAR 06 84	0.30	0.31	0.31	0.33	0.31
MAR 20 84	0.25	0.24	0.25	0.25	0.25
APR 03 84	0.26	0.26	0.78	0.28	0.29
APR 17 84	0.28	0.26	0.23	0.27	0.24
MAY 01 84	0.74	0.70	2.4	0.71	0.76
MAY 15 84	0.24	0.26	1.4	0.26	0.27
JUN 05 84	0.24	0.24	0.22	0.24	0.23
JUN 15 84	0.54	0.51	0.94	0.51	0.52
JUL 02 84	0.33	0.35	1.2	0.35	0.36
JUL 16 84	0.94	0.86	1.6	0.93	0.86
AUG 02 84	0.25	0.23	1.3	0.28	0.23
AUG 23 84	0.20	0.21	1.3	0.83	0.25
SEP 13 84	0.26	0.31	1.30	0.35	0.29
SEP 27 84	0.27	0.27	0.28	0.28	0.27
OCT 16 84	0.26	0.27	0.45	0.27	0.28
OCT 30 84	0.25	0.25	0.86	0.55	0.30
NOV 13 84	0.22	0.21	0.35	0.28	0.23
NOV 27 84	0.26	0.46	0.70	0.54	0.44
DEC 04 84	0.22	0.24	0.88	0.45	0.31
DEC 20 84	0.22	0.21	0.24	0.23	0.24

Table 16

Soluble Orthophosphate (mg/L-P) Values from the Cedar River Near the Duane Arnold Energy Center During 1984

	Sampling Location				
Date	Upstream of Plant 1	Upstream of Plant Intake 2	Discharge Canal 5	140 ft. Downstream of Discharge 3	1/2 Mile Downstream from Plant 4
JAN 10 84	0.14	0.13	0.14	0.14	0.14
JAN 24 84	0.19	0.19	0.21	0.21	0.21
FEB 07 84	0.19	0.19	0.50	0.23	0.20
FEB 21 84	0.28	0.28	0.28	0.28	0.29
MAR 06 84	0.16	0.15	0.16	0.16	0.16
MAR 20 84	0.19	0.20	0.22	0.19	0.19
APR 03 84	0.15	0.15	0.55	0.15	0.15
APR 17 84	0.14	0.13	0.13	0.12	0.14
MAY 01 84	0.15	0.15	0.19	0.15	0.15
MAY 15 84	0.07	0.07	0.52	0.07	0.08
JUN 05 84	0.07	0.07	0.07	0.07	0.07
JUN 15 84	0.28	0.26	0.48	0.27	0.27
JUL 02 84	0.13	0.14	0.46	0.14	0.15
JUL 16 84	0.13	0.13	0.23	0.13	0.12
AUG 02 84	0.02	0.01	0.47	0.03	0.02
AUG 23 84	0.03	0.02	0.49	0.27	0.01
SEP 13 84	0.01	0.01	0.48	0.06	0.01
SEP 27 84	0.14	0.14	0.15	0.14	0.14
OCT 16 84	0.12	0.12	0.16	0.12	0.12
OCT 30 84	0.21	0.21	0.54	0.38	0.24
NOV 13 84	0.19	0.20	0.26	0.23	0.20
NOV 27 84	0.16	0.15	0.28	0.20	0.16
DEC 04 84	0.10	0.08	0.52	0.20	0.10
DEC 20 84	0.15	0.15	0.17	0.15	0.16

Table 17

Ammonia (mg/L-N) Values from the Cedar River Near the Duane Arnold Energy Center During 1984

Date	Sampling Location: Upstream of Plant 1	Upstream of Plant Intake 2	Discharge Canal 5	140 ft. Downstream of Discharge 3	1/2 Mile Downstream from Plant 4
JAN 10 84	0.35	0.33	0.34	0.36	0.36
JAN 24 84	0.18	0.19	0.19	0.20	0.26
FEB 07 84	0.18	0.18	0.03	0.16	0.18
FEB 21 84	0.41	0.42	0.43	0.42	0.42
MAR 06 84	0.10	0.10	0.09	0.10	0.09
MAR 20 84	0.21	0.20	0.18	0.21	0.21
APR 03 84	0.12	0.12	0.20	0.11	0.12
APR 17 84	0.08	0.04	0.08	0.05	0.06
MAY 01 84	0.14	0.13	0.12	0.15	0.13
MAY 15 84	0.01	0.03	0.07	0.04	0.03
JUN 05 84	0.01	0.01	0.01	0.01	0.01
JUN 15 84	0.06	0.07	0.07	0.08	0.11
JUL 02 84	0.03	0.05	0.03	0.03	0.04
JUL 16 84	0.03	0.03	0.04	0.03	0.03
AUG 02 84	<0.01	<0.01	0.01	<0.01	<0.01
AUG 23 84	0.03	0.04	0.47	0.15	0.12
SEP 13 84	0.01	0.03	0.24	0.05	0.02
SEP 27 84	0.03	0.02	0.05	0.02	0.07
OCT 16 84	0.04	0.04	0.20	0.08	0.09
OCT 30 84	<0.01	<0.01	0.02	<0.01	<0.01
NOV 13 84	0.05	0.05	0.06	0.06	0.05
NOV 27 84	0.05	0.06	0.07	0.06	0.05
DEC 04 84	0.07	0.04	0.06	0.04	0.03
DEC 20 84	0.09	0.09	0.08	0.08	0.08

Table 18

Nitrate (mg/L-N) Values from the Cedar River Near the Duane Arnold Energy Center During 1984

Date	Sampling Location				
	Upstream of Plant 1	Upstream of Plant Intake 2	Discharge Canal 5	140 ft. Downstream of Discharge 3	1/2 Mile Downstream from Plant 4
JAN 10 84	7.1	7.1	7.0	7.0	7.1
JAN 24 84	7.2	7.3	7.6	7.7	7.6
FEB 07 84	6.5	7.0	12.0	7.2	6.5
FEB 21 84	4.8	4.8	4.8	4.8	4.7
MAR 06 84	6.9	7.1	7.4	7.3	7.3
MAR 20 84	6.4	6.4	7.1	6.5	6.5
APR 03 84	6.7	6.6	13.0	6.8	6.8
APR 17 84	8.8	8.7	7.4	8.6	8.7
MAY 01 84	7.3	7.1	7.9	7.3	7.0
MAY 15 84	7.9	7.9	21.0	7.9	7.9
JUN 05 84	9.6	9.6	8.5	9.5	9.7
JUN 15 84	9.5	9.2	15.0	9.3	9.3
JUL 02 84	8.5	8.7	17.0	8.5	8.4
JUL 16 84	6.4	6.5	13.0	6.6	6.6
AUG 02 84	4.4	4.6	1.4	5.1	5.0
AUG 23 84	2.0	1.9	8.0	5.4	2.2
SEP 13 84	1.2	1.1	3.3	1.2	1.2
SEP 27 84	1.4	1.4	1.6	1.4	1.5
OCT 16 84	3.0	3.0	2.4	2.8	3.1
OCT 30 84	4.6	4.6	7.1	5.8	4.8
NOV 13 84	5.6	5.5	5.7	5.7	5.6
NOV 27 84	5.4	5.4	6.3	5.7	5.6
DEC 04 84	4.9	4.9	10.0	6.3	5.2
DEC 20 84	6.5	6.4	6.8	6.7	6.6

Table 19

Total Iron (mg/L) Values from the Cedar River
Near the Duane Arnold Energy Center During 1984

Date	Sampling Location: Upstream of Plant 1	Upstream of Plant Intake 2	Discharge Canal 5	140 ft. Downstream of Discharge 3	1/2 Mile Downstream from Plant 4
JAN 10 84	0.18	0.16	0.22	0.20	0.18
JAN 24 84	0.08	0.08	0.34	0.83	0.08
FEB 07 84	0.11	0.12	0.39	0.16	0.13
FEB 21 84	3.2	2.8	2.6	2.9	2.9
MAR 06 84	0.68	0.63	0.52	0.66	0.64
MAR 20 84	0.86	0.93	0.86	0.96	0.99
APR 03 84	1.2	1.2	2.4	1.2	1.2
APR 17 84	1.1	1.1	1.0	1.0	1.1
MAY 01 84	7.0	7.0	16.0	7.5	8.0
MAY 15 84	1.2	1.2	3.1	1.3	1.2
JUN 05 84	2.1	2.4	2.0	2.3	2.3
JUN 15 84	7.0	4.6	11.0	6.0	6.0
JUL 02 84	1.4	1.6	3.2	1.6	1.5
JUL 16 84	9.9	6.7	10.0	5.9	7.8
AUG 02 84	1.2	1.2	3.4	1.3	1.2
AUG 23 84	0.62	0.91	2.4	1.7	0.91
SEP 13 84	0.40	0.47	1.10	0.48	0.44
SEP 27 84	0.35	0.38	0.42	0.36	0.32
OCT 16 84	0.40	0.45	0.45	0.34	0.60
OCT 30 84	0.34	0.33	0.76	0.35	1.10
NOV 13 84	0.41	0.44	0.53	0.47	0.39
NOV 27 84	0.54	0.46	0.65	0.51	0.49
DEC 04 84	0.19	0.26	0.48	0.32	0.28
DEC 20 84	0.45	0.60	0.57	0.66	0.53

Table 20

Biochemical Oxygen Demand (5-Day) (mg/L) Values from the Cedar River Near the Duane Arnold Energy Center During 1984

	Sampling Locations				
Date	Upstream of Plant 1	Upstream of Plant Intake 2	Discharge Canal 5	140 ft. Downstream of Discharge 3	1/2 Mile Downstream from Plant 4
JAN 10 84	2	2	2	2	2
JAN 24 84	<1	1	1	2	1
FEB 07 84	2	1	1	2	<1
FEB 21 84	6	6	6	6	6
MAR 06 84	3	2	<1	1	<1
MAR 20 84	3	3	3	2	3
APR 03 84	3	2	3	3	3
APR 17 84	3	3	3	2	3
MAY 01 84	3	3	7	3	3
MAY 15 84	4	4	12	4	4
JUN 05 84	3	3	2	3	3
JUN 15 84	3	3	4	3	3
JUL 02 84	2	2	6	2	2
JUL 16 84	4	4	6	4	4
AUG 02 84	6	6	8	6	6
AUG 23 84	8	7	12	9	8
SEP 13 84	12	13	18	14	12
SEP 27 84	10	9	10	9	10
OCT 16 84	4	3	5	3	3
OCT 30 84	1	1	2	2	1
NOV 13 84	3	2	2	2	2
NOV 27 84	2	3	3	3	3
DEC 04 84	4	4	7	5	5
DEC 20 84	1	2	2	2	2

Table 21

Coliform Bacteria (Total, org/100 ml) Values from the Cedar River Near the Duane Arnold Energy Center During 1984

Date	Upstream of Plant 1	Upstream of Plant Intake 2	Discharge Canal 5	140 ft. Downstream of Discharge 3	1/2 Mile Downstream from Plant 4
	Sampling Locations				
JAN 10 84	800	1200	500	1200	1400
JAN 24 84	2000	7000	4000	3000	4000
FEB 07 84	1600	2100	470	1500	1700
FEB 21 84	1300	2000	1000	1900	2300
MAR 06 84	3400	3400	1000	3000	2800
MAR 20 84	1900	1700	1200	1900	2100
APR 03 84	1000	1100	1400	1200	1900
APR 17 84	10000	7000	10000	2200	7000
MAY 01 84	9000	3500	13000	2700	3500
MAY 15 84	600	500	4000	300	700
JUN 05 84	1100	900	800	1500	1300
JUN 15 84	7000	10000	9000	10000	8000
JUL 02 84	5000	3000	5000	5000	4000
JUL 16 84	20000	30000	50000	40000	40000
AUG 02 84	700	600	1300	800	800
AUG 23 84	700	600	1500	1400	800
SEP 13 84	1000	300	1400	4000	2000
SEP 27 84	4200	4900	3500	4500	3900
OCT 16 84	3000	1700	2000	700	1000
OCT 30 84	2800	1100	1300	1200	1600
NOV 13 84	900	1100	1000	1200	1900
NOV 27 84	1600	1000	1500	1600	2300
DEC 04 84	900	1700	600	2200	1700
DEC 20 84	5000	1000	1700	1800	1400

Table 22

Coliform Bacteria (Fecal, org/100 ml) Values from the Cedar River Near the Duane Arnold Energy Center During 1984

Date	Sampling Locations: Upstream of Plant 1	Upstream of Plant Intake 2	Discharge Canal 5	140 ft. Downstream of Discharge 3	1/2 Mile Downstream from Plant 4
JAN 10 84	310	220	190	160	160
JAN 24 84	690	1200	940	840	1000
FEB 07 84	390	510	140	420	390
FEB 21 84	510	260	220	210	400
MAR 06 84	68	52	16	80	110
MAR 20 84	200	330	140	280	3000
APR 03 84	96	100	70	100	96
APR 17 84	360	240	110	220	180
MAY 01 84	2000	2400	2700	2200	1800
MAY 15 84	20	16	210	20	28
JUN 05 84	160	110	60	120	90
JUN 15 84	2500	1200	2100	700	1600
JUL 02 84	600	400	400	500	400
JUL 16 84	4900	5300	10000	4500	4600
AUG 02 84	200	<100	100	400	100
AUG 23 84	10	40	400	500	30
SEP 13 84	100	<100	1000	<100	100
SEP 27 84	3500	1100	3300	3900	3000
OCT 16 84	330	230	230	180	170
OCT 30 84	290	410	410	290	250
NOV 13 84	110	60	90	40	90
NOV 27 84	150	160	110	80	90
DEC 04 84	180	130	100	150	200
DEC 20 84	130	120	110	70	170

Table 23

Heavy Metal Determinations

Station	Cr^{+6}	Cu	Pb	Mn	Hg	Zn
			April 17 Metals (µg/L)			
1. Lewis Access	<10	<10	<10	60	<1	60
2. Upstream DAEC	<10	<10	<10	70	<1	40
3. Downstream DAEC	<10	<10	<10	70	<1	20
4. ½ Mile Below Plant	<10	<10	<10	60	<1	20
5. Discharge Canal	<10	<10	<10	60	<1	20
			July 16			
1. Lewis Access	<50	40	10	610	<1	110
2. Upstream DAEC	<50	40	10	520	<1	70
3. Downstream DAEC	<50	30	10	530	<1	160
4. ½ Mile Below Plant	<50	40	<10	500	<1	60
5. Discharge Canal	<50	30	<10	670	<1	50
			October 16			
1. Lewis Access	<50	<10	<10	110	<1	20
2. Upstream DAEC	<50	<10	<10	130	<1	10
3. Downstream DAEC	<50	<10	<10	110	<1	50
4. ½ Mile Below Plant	<50	<10	<10	90	<1	40
5. Discharge Canal	<50	<10	<10	140	<1	50

Table 24

Summary of Benthic Organisms Collected from the Cedar River Near the Duane Arnold Energy Center From Natural and Artificial Substrates

SUMMER 1984	Artificial Substratres (Hester-Dendy)												Natural Substrates (Ponar)	
	Location 1			Location 2			Location 3			Location 5				
	1A	1B	1C	2A	2B	2C	3A	3B	3C	5A	5B	5C	Location 2	Location 3
Trichoptera														
Hydropsyche sp.	10						6	4		10	--	6	-	-
H. orris	164						8	21		9	6	2	2	-
H. simulans	53						26	27		--	8	7	3	-
Potamyia flava	84						29	51		38	49	34	2	-
Nectopsyche sp.	--						--	--		1	--	--	-	-
Ephemeroptera														
Baetis sp.	--						--	4		--	--	--	-	-
Caenis sp.	14						57	59		10	23	20	-	-
Isonychia sp.	9						212	207		199	145	182	-	-
Tricoythode sp.	--						17	22		--	--	2	-	-
Heptagenia sp.	4						--	--		1	--	--	-	-
H. diabasia	--						3	--		--	1	1	-	-
H. flavescen	3						--	--		--	--	--	-	-
Stenacron sp.	--						--	2		--	--	2	-	-
Stenonema sp.	2						6	11		4	3	--	-	-
S. exiguum	--						7	3		5	--	3	-	-
S. integrum	--						15	29		24	35	18	-	-
S. puchellum	--						--	--		8	--	5	-	-
Diptera														
Chironomidae	15						10	12		18	11	14	4	2
Simulium sp.-larvae	262						5	4		--	--	3	-	1
Simulium sp.-pupae	225						--	--		4	--	2	-	-
Odonata														
Argia sp.	--						--	1		--	--	--	-	-
Coleoptera														
Stenelmis sp.-larvae	--						--	2		--	--	--	-	-
Stenelmis sp.-adult	--						--	--		--	--	--	-	-

Table 24 cont.

SUMMER 1984	Artifical Substrates (Hester-Dendy)												Natural Substrates (Ponar)	
	Location 1			Location 2			Location 3			Location 5				
	1A	1B	1C	2A	2B	2C	3A	3B	3C	5A	5B	5C	Location 2	Location 3
Amphipoda														
Gammarus sp.	--						--	--		3	4	--	-	-
Total No. of Organisms	845						401	459		334	285	301	11	3
Total No. of Species	12						13	16		14	10	15	4	2
FALL 1984														
Trichoptera														
Hydropsyche sp.	50	32		32	87		7	12	9	2	--	--	6	4
Hydropsyche orris	340	233		161	304		17	69	69	--	--	2	1	-
Hydropsyche simulans	192	151		78	137		14	73	44	11	--	5	-	-
Potamyia flava	165	87		29	169		21	27	20	39	1	53	-	-
Ephemeroptera														
Baetis sp.	--	2		2	--		--	--	--	--	--	--	-	-
Baetis intercalarus	5	3		--	2		--	1	--	--	--	--	-	-
Isonychia sp.	--	2		--	3		--	--	--	--	--	--	-	-
Heptagenia sp.	3	--		--	16		--	5	--	--	--	--	-	-
Heptagenia flavescens	37	35		16	17		5	18	6	--	--	--	-	-
Leptophlebia sp.	--	--		--	--		1	--	--	--	--	--	-	-
Potamanthus sp.	--	--		--	--		--	2	1	--	--	--	-	-
Stenonema sp.	33	4		5	12		4	--	4	2	--	--	-	-
Stenonemia integrum	5	--		--	2		--	2	--	--	--	--	-	-
Stenonemia puchellum	40	14		7	22		7	6	7	--	--	--	-	-
Stenonema terminatum	7	6		2	13		8	15	7	2	--	2	-	-
Tricorythodes sp.	--	--		--	--		1	--	--	--	--	--	-	-
Plecoptera														
Acroneuria sp.	5	5		3	35		3	8	1	--	--	--	-	-
Odonata														
Argia sp.	--	--		--	--		1	--	--	8	--	5	-	-

Table 24 cont.

FALL 1984	Artificial Substrates (Hester-Dendy)												Natural Substrates (Ponar)	
	Location 1			Location 2			Location 3			Location 5				
	1A	1B	1C	2A	2B	2C	3A	3B	3C	5A	5B	5C	Location 2	Location 3
Diptera														
Chironomidae	212	21		120	69*		160	137	50*	90	--	123	26	27
Simulium sp.-larvae	29	35		21	10		--	5	--	--	--	1	-	-
Simulium sp.-pupae	17	28		--	8		1	8	--	4	--	17	-	-
Hemiptera														
Corixidae	--	--		--	--		--	--	--	--	1	--	-	-
Oligocaeta														
Naididae	--	--		--	--		--	--	20	30	--	--	-	-
Tubificidae	--	--		--	--		--	--	5	--	--	--	-	-
Gastropoda														
Physa sp.	--	4		--	--		--	1	2	162	3	157	-	-
Coleoptera														
Stenelmis sp.-larvae	--	3		1	2		--	--	--	--	--	--	-	-
Stenelmis sp.-adult	--	2		13	14		--	--	--	--	--	--	-	-
Megaloptera														
Corydalus cornatus	--	--		1	--		--	--	--	--	--	--	-	-
Total No. of Organisms	1140	667		490	922		250	389	245	350	6	365	33	31
Total No. of Species	15	18		14	18		14	16	14	10	4	9	3	2

Table 25

Daily Numbers of Fish Impinged at the
Duane Arnold Energy Center, January - December 1984

Day of the Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0	1	1	3	2	0	0	0	8	1	1	2
2	0	1	4	0	2	0	0	0	3	1	0	1
3	2	3	2	2	0	0	0	0	12	0	0	17
4	2	4	3	3	0	0	0	0	6	0	0	23
5	6	0	0	0	0	0	3	0	11	0	2	0
6	6	0	4	3	0	0	2	0	4	0	0	0
7	11	0	1	1	0	0	2	0	3	0	1	1
8	2	0	3	0	0	0	2	0	1	0	0	1
9	2	6	7	3	1	0	0	0	5	0	0	2
10	1	1	5	0	1	0	1	0	1	0	0	4
11	3	2	8	3	0	0	0	0	6	0	1	3
12	0	4	6	0	0	0	2	0	4	0	1	4
13	3	3	7	0	0	0	0	0	0	0	2	4
14	2	4	8	0	0	0	0	0	2	0	0	4
15	4	4	12	0	0	0	1	0	0	0	0	1
16	5	0	5	1	0	0	0	1	1	0	2	6
17	1	2	2	0	0	0	0	0	1	0	0	7
18	1	0	8	0	0	0	0	4	3	0	1	2
19	0	4	5	0	0	0	0	4	1	0	4	10
20	0	0	2	0	0	0	0	13	3	0	1	0
21	0	0	6	0	0	1	0	13	3	0	8	4
22	6	3	3	0	0	0	2	5	0	0	7	2
23	3	0	18	0	1	0	0	1	0	0	5	1
24	9	0	4	0	0	0	0	17	0	0	1	0
25	1	1	6	0	0	0	0	20	0	1	0	5
26	2	0	2	0	0	0	0	20	0	0	1	1
27	0	1	4	0	0	0	0	10	1	1	0	1
28	1	1	4	0	0	0	1	9	0	0	4	2
29	5	3	2	0	0	0	0	19	0	0	3	5
30	0	–	2	0	0	0	0	16	0	0	1	8
31	7	–	4	–	0	–	0	11	–	0	–	5
TOTAL	89	48	148	19	7	1	16	163	79	4	46	126

ANNUAL TOTAL 746

Table 26

Comparison of Average Yearly Values for Several Parameters in the Cedar River Upstream of DAEC* 1972-1984

Year	Mean Flow (cfs)	Turbidity (STU)	Total PO_4 (mg/L)	Ammonia (mg/L-N)	Nitrate (mg/L-N)	BOD_5 (mg/L)
1972	4,418	22	1.10	0.56	0.23	5.7
1973	7,900	28	0.84	0.36	1.5	4.0
1974	5,580	29	2.10	0.17	4.2	4.7
1975	4,206	58	1.08	0.33	2.8	6.5
1976	2,082	41	0.25	0.25	2.8	7.3
1977	1,393	15	0.33	0.52	2.9	6.5
1978	3,709	23	0.26	0.22	4.4	3.3
1979	7,041	26	0.29	0.12	6.6	2.5
1980	4,523	40	0.34	0.19	5.4	4.3
1981	3,610	33	0.77	0.24	6.0	6.5
1982	7,252	43	0.56	0.23	8.0	5.1
1983	8,912	22	0.25	0.10	8.6	3.3
1984	7,325	40	0.32	0.10	5.9	3.9

* Data from Lewis Access location (Station 1)

Table 27

Summary of Relative Loading Values (Average Annual Concentration x Cumulative Runoff(for Several Parameters in the Cedar River Upstream of DAEC* 1972-1984

Year	Mean Flow (cfs)	Cumulative Runoff (in.)	Turbidity	Relative Loading Values: Total PO_4	Ammonia	Nitrate	BOD_5
1972	4,418	9.24	203	10.2	5.2	2	53
1973	7,900	16.48	461	13.8	5.9	25	66
1974	5,580	11.64	338	24.4	2.0	49	55
1975	4,206	8.77	509	9.5	2.9	25	57
1976	2,082	4.35	178	1.1	1.1	12	32
1977	1,393	2.91	44	1.0	1.5	8	19
1978	3,709	7.74	178	2.0	1.7	34	26
1979	7,041	14.79	385	4.3	1.8	98	37
1980	4,523	9.45	378	3.2	1.8	51	41
1981	3,610	7.53	248	5.8	1.8	45	49
1982	7,252	15.13	651	8.5	3.5	121	77
1983	8,912	18.00	396	4.5	1.8	155	59
1984	7,325	15.22	609	4.9	1.5	90	59

* Data from Lewis Access location (Station 1)